Three-dimensional velocity structure beneath the Japan Islands

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1. Introduction

Determination with three-dimensional (3-D) velocity structure is important in the 3-D heterogeneous structure such as Japan Islands where the Pacific (PAC) and Philippine Sea (PHS) plates subducting. We estimated the 3-D P- and S-wave velocity structure beneath the Japan Islands using the data of the high-sensitivity seismograph network of Japan (Hi-net) of National Research Institute for Earth Science and Disaster Prevention (NIED) with seismic tomography.

2. Data

The target area is 29-46N, and 129-146E. We used manually picked 3,173,160 P- and 2,510,561 S-wave arrival time data from 78,324 earthquakes whose epicentral distance to the nearest seismic station is less than 50 km.

3. Method

We used the seismic tomography (Zhao et al., 1992) with spatial correlation (Matsubara et al., 2004; 2005). Horizontal grid interval is 0.1 degree and resolution is 0.2 degree because of the smoothing factor. The grid interval of the vertical direction is 2.5 km (Depth (D) = 0-10 km), 5 km (D = 10-40 km), 10 km (D = 40-60 km), 15 km (D = 60- km). We assumed no velocity discontinuity. The initial velocity model is the that used in the NIED Hi-net.

4. Result

Subducting PAC plate is clearly imaged to the depths around 180 km with high velocities beneath the northeastern (NE) Japan arc. The heterogeneous structure in the PAC plate is also imaged such as extremely low-velocity zone beneath the southern Hidaka Mountains and between the Hokkaido and Honshu Islands at depths of 50-80 km. The low velocity zone in the PAC plate exist near the hypocentral region of the 2003 Off Miyagi earthquake such as earthquakes connect the double seismic zone. Beneath the NE Japan, high Vp/Vs zone exist along the volcanic front at depths of 20-30 km.

Beneath the central Japan, subducting PAC plate is clearly imaged to the depths around 300 km and subducting PHS plate is clearly imaged to the depths around 180 km with high velocities. At depths of 15-30 km, low-velocity zone exist beneath the volvanoes. High Vp/Vs zone continuously exist from the depth of 20 to 150 km beneath the Mt. Yatsugatake.

Beneath the southwestern (SW) Japan, subducting PHS plate is clearly imaged to the depths around 30-70 km with high velocities. Improved resolution in depth direction enables to image the low-velocity zone of the oceanic crust at the uppermost part of the subducting PHS plate.

From central to SW Japan, deep low-frequency tremors are found by Obara (2002) at depths of 30-35 km. They seem to have relation to high Vp/Vs zone. Beneath the Tokai region and Kii peninsula they occur in the high Vp/Vs zone, beneath the eastern part of Shikoku they occur at northern part of the high Vp/Vs zone, and beneath the western part of Shikoku they occur in the southern part of the high Vp/Vs zone. At the central part of Shikoku, there is a region where the deep low frequency tremors rarely occur. There is no high Vp/Vs zone near the subducting PHS plate.

Beneath the Kyushu, steeply subducting PHS plate is clearly imaged to the depths around 250 km with high velocities.

5. Summary

Many data enable to image the plate boundary clearly without the forced constrain such as the velocity discontinuity. The heterogeneous structure in the subducting plate is also imaged in detail. We can define the upper boundary of subducting plates with these 3-D velocity structure and hypocentral distribution determined with these 3-D structure.